3.5 ENERGY

This analysis provides an overview of the potential operation and construction impacts associated with both the general overall use of energy and the more specific use of electrical energy for the existing conditions and the No Project, Modal, and High-Speed Train (HST) Alternatives.

3.5.1 Regulatory Requirements and Methods of Evaluation

A. REGULATORY REQUIREMENTS

Federal Regulations
Federal Energy Regulatory Commission: The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. FERC also regulates natural gas and hydropower projects. As part of that responsibility, FERC regulates the transmission and sale of natural gas for resale in interstate commerce, the transmission of oil by pipeline in interstate commerce, and the transmission and wholesale sales of electricity in interstate commerce. FERC also licenses and inspects private, municipal, and state hydroelectric projects; approves the siting of and abandonment of interstate natural gas facilities, including pipelines, storage, and liquefied natural gas; oversees environmental matters related to natural gas and hydroelectricity projects and major electricity policy initiatives; and administers accounting and financial reporting regulations and conduct of regulated companies.

Corporate Average Fuel Economy Standards: Corporate Average Fuel Economy (CAFE) standards are federal regulations that are set to reduce energy consumed by on-road motor vehicles. The standards specify minimum fuel consumption efficiency standards for new automobiles sold in the United States. The current standard for passenger cars is 27.5 miles per gallon (mpg) (44.3 kilometers per gallon [kpg]). The 1998 standard for light trucks was 20.7 mpg (33.3 kpg) (Competitive Enterprise Institute 1996). In April 2002, the National Highway Traffic Safety Administration, part of the U.S. Department of Transportation (DOT), issued a final rule for CAFE standards for model-year 2004 light trucks that codified a standard of 20.7 mpg (33.3 kpg); this level is now in effect (U.S. Department of Transportation 2002a).

Transportation Equity Act for the 21st Century: The Transportation Equity Act for the 21st Century (TEA21), passed in 1998, builds on the initiatives established in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which was the prior authorizing legislation for surface transportation. The ISTEA identified planning factors for use by Metropolitan Planning Organizations (MPOs) in developing transportation plans and programs. Under the ISTEA, MPOs are required to "protect and enhance the environment, promote energy conservation, and improve quality of life" and are required to consider the consistency of transportation planning with federal, state, and local energy goals (U.S. Department of Transportation 2002b).

Section 403(b) of the Power Plant and Industrial Fuel Use Act of 1978 (P.L. 95-620): This section of the Power Plant and Industrial Fuel Use Act encourages conservation of petroleum and natural gas by recipients of federal financial assistance.

Executive Order 12185, Conservation of Petroleum and Natural Gas (December 17, 1979, 44 F.R. § 75093): This executive order encourages additional conservation of petroleum and natural gas by recipients of federal financial assistance.

State Regulations
Public Resources Code Section 21100(b)(3) provides that an EIR shall include a statement setting forth the mitigation measures proposed to minimize the significant effects on the environment, including measures to reduce the wasteful, inefficient, and unnecessary consumption of energy. Appendix F to the California Environmental Quality Act (CEQA) Guidelines addresses energy conservation goals, notes that potentially significant energy implications of a project should be considered in an EIR, and contains general examples of mitigation measures for a project's potentially significant energy impacts.

CEQA Guidelines Section 15126.2 discusses requirements for an EIR to address potentially significant effects, and although it does not include energy specifically, it mentions use of nonrenewable resources. CEQA Guidelines Section 15126.4(a)(1)(C) requires an EIR to discuss energy conservation measures, if relevant.

California Code of Regulations, Title 24, Part 6, Energy Efficiency Standards: Title 24, Part 6 of the California Code of Regulations, Energy Efficiency Standards, promotes efficient energy use in new buildings constructed in California. The standards regulate energy consumed for heating, cooling, ventilation, water heating, and lighting. The standards are enforced through the local building permit process. These standards may apply to any buildings (e.g., stations) constructed as part of or in association with the No Project, Modal, and HST Alternatives.

B. METHOD OF EVALUATION OF IMPACTS

This evaluation of energy supply and demand compares potential energy use for intercity travel of the proposed alternatives. This section explains the methodology used to evaluate the potential energy impacts and benefits attributable to operation (direct energy) and construction (indirect energy) of the alternatives under study. This section also explains the criteria used to determine whether a potential impact on energy consumption would be significant. The evaluation is based on available data and forecasts.

Direct Energy
Analyses were performed as described below to determine the operational impact of the alternatives on overall statewide transportation-related energy supply[1] and statewide electricity supply during peak demand.

Overall Statewide Transportation-Related Energy Supply: Overall direct energy consumption by the alternatives involves potential energy use by the operation of vehicles (automobiles, airplanes, and HSTs) and related infrastructure in the state. The potential direct impacts on overall transportation-related energy supply were evaluated both quantitatively and qualitatively.

The quantitative analysis focused on the direct relationship between projected vehicle miles traveled (VMT) and energy consumption to estimate the potential change in total energy consumption between the No Project, Modal, and HST Alternatives. Only intercity trips that would be served by the HST system, including some long-distance commute trips, were considered when modeling VMT. Local commute and other regional and intercity trips were not considered. The quantitative assessment of direct energy impacts considered the following.

- VMT for automobiles, airplanes, and HST within the study area, as described below in Section 3.5.2 (consistent with the analysis conducted for Section 3.3, Air Quality).
- Variation of fuel consumption rates by vehicle type.

[1] *Overall energy* refers to the combination of energy derived from petroleum fuels and electrical energy.

Ridership projections for the HST system varied between 42 million and 68 million passengers (including 10 million long-distance commuters) for 2020, with potential for significantly higher ridership beyond 2020. The figures on the lower end of these estimates are considered investment-grade forecasts and are based conservatively on year 2000 costs, travel times, and congestion levels of air and automobile transportation. The figures on the higher end are based on a sensitivity analysis, which assumes the increased costs and congestion associated with air and automobile travel would result in greater potential ridership for the proposed intercity HST. The sensitivity analysis assumed investment-grade ridership forecasts and applied variations in mode characteristics that would tend to increase HST ridership and revenue in order to determine how sensitive HST ridership would be to increases in air and automobile rates of travel, air and automobile travel times, and airfares. This sensitivity analysis produced a higher ridership forecast, which is used in this Program EIR/EIS to estimate or project a maximum impact potential for the Modal and HST Alternatives.

For this Program EIR/EIS, the higher demand forecast of 68 million riders (58 million intercity trips and 10 million commute trips), based on the sensitivity analysis, offers a more reasonable estimate to represent total capacity of the proposed HST system, while serving as a representative worst-case scenario for defining the physical and operational aspects of the alternatives in 2020. This higher forecast is generally used as a basis for defining the Modal and HST Alternatives and is referred to in this report as the representative demand. In some specific analyses, such as this energy analysis, the high-end forecasts result in a benefit because the additional HST riders would make the HST more energy efficient (i.e., it would use less energy per passenger), thus creating a higher energy benefit to the overall intercity transportation system than the low-end (investment-grade) forecasts. In cases where the investment-grade forecasts result in greater impact levels than would result with representative demand, additional analysis is included to address the differences in potential energy impacts between what is expected under each of the ridership scenarios.

Projections of HST ridership and the number of trips that would otherwise use other modes were calculated and reported by Charles Rivers Associates in *Independent Ridership and Passenger Revenue Projections for High Speed Rail Alternatives in California* (California High Speed Rail Authority 2000). These projections were the basis for determining projected statewide VMT for each mode. Projections in the ridership report were based on surveys of current intercity air, conventional rail, and private vehicle travelers, historical and forecast population, income, traffic data, and an airline simulation model. HST trip durations and departure frequencies, fares, station locations, and amenities also affected ridership projections.

This energy analysis applies the higher-end forecasts from the Charles River Associates' sensitivity analysis. Automobile VMT modeling for the proposed HST Alternative was developed as part of this Program EIS/EIR and used to develop VMT values for existing conditions and the No Project and Modal Alternatives.

The VMT fuel consumption method used herein is outlined in the *Technical Guidance*, Section 5309 New Starts Criteria (Federal Transit Authority, Office of Planning 1999). Energy consumption factors for the first two modes identified in Table 3.5-1 were developed by Oak Ridge Laboratory and published in the 2002 *Transportation Energy Book* (Edition 22) (Oak Ridge Laboratory 2002). These results are based on national averages for road, traffic, and weather conditions, and are intended for general comparisons. The energy consumption factor for the HST mode is based on energy used by similarly designed trains, such as the Trains à Grande Vitesse in France and the Intercity Express in Germany (DE Consult 2003). This report assumes a 16-car trainset (engines and cars) with a 1,200-passenger carrying capacity.

Table 3.5-1
Direct Energy Consumption Factors

Mode	Factor
Passenger vehicles (auto, van, light truck)[a]	5,669 Btus/VMT
Airplanes[a]	334,086 Btus/VMT
High-speed trains[b]	924,384 Btus/VMT

Btus = British thermal units

Sources:
[a] Oak Ridge Laboratory 2002; based on nationally averaged conditions and fleet composition.
[b] DE Consult 2003, based on a 16-vehicle trainset.

Overall direct energy, measured in British thermal units (Btus), was converted to equivalent barrels of crude oil to represent potential energy impact and/or savings. (Btus are the standard units used by industry and government literature for such comparisons. Metric units for energy [i.e., Joules] are not used in this report.) Annual direct-energy consumption values for intercity travel were calculated for existing conditions and the No Project, Modal, and HST Alternatives, and compared. The potential change in commuter-derived direct energy consumption from the future No Project condition (in Btus) was calculated for the Modal and HST Alternatives.

The qualitative analysis of overall direct energy consumption considers the estimated or assumed levels of service for each of the alternatives and the effect that each would have on congestion and travel speeds, which would have a substantial impact on fuel efficiency and, therefore, energy use.

In addition to the overall direct energy analysis, average energy consumption per passenger mile was calculated for each of the transportation modes essential to the development of the Modal and HST Alternatives.

Statewide Electricity Supply During Period of Peak Demand: For the HST Alternative, peak-period electricity demand was determined using an energy consumption factor for HSTs obtained from DE Consult Peer Review Report (DE Consult 2000) and the operation plan from the California High Speed Rail Authority's (Authority's) final business plan (Business Plan). The demand was calculated in terms of megawatts and compared to current estimates of peak demand and supply capacity within grid controlled by the California Independent State Operator (Cal-ISO). Peak demand for electricity for the future No Project and Modal Alternatives is discussed qualitatively, as it is not possible to measure at the program level. This approach is reasonable because the possible increase in transportation-related electricity use associated with these alternatives would likely be small and considered insignificant.

Indirect Energy

The indirect energy impacts considered here include two potential construction-related energy consumption factors: construction of proposed alternatives and construction of secondary facilities.

Construction of Alternatives: Projected construction-related energy consumption refers to energy used for the construction of HST trackway and support facilities under the HST Alternative and highway expansion and airport runway improvements under the Modal Alternative, and transportation of materials and equipment to and from the work site. Construction-related energy consumption factors for the proposed HST system cannot be compiled because of the relative dearth of available HST examples from which to draw data. Data gathered for typical heavy rail systems and a heavy rail commuter system, San Francisco Bay Area Rapid Transit District (BART), were used to estimate projected construction-related energy consumption of the proposed HST system. Projected construction-related energy consumption for the Modal and HST Alternatives is presented in Table 3.5-2. These estimates are appropriate for comparison purposes.

The construction energy payback period measures the number of years that would be required to pay back the energy used in construction with operational energy consumption savings. The payback period was calculated for this section by dividing the estimate of each alternative's construction energy by the amount of energy that would later be saved by each of the proposed alternatives compared to the No Project condition. It was assumed that the amount of energy saved in the study year (2020) would remain constant throughout the payback period.

Table 3.5-2
Construction-Related Energy Consumption Factors

Mode	Facility	Rural Compared to Urban[f]	Factor (billions of Btus)
Modal Alternative			
Automobile	Highway (at grade)	Rural[a]	17.07/one-way lane mi
		Urban[b]	26.28/one-way lane mi
	Highway (elevated)	Rural[a]	130.38/one-way lane mi
		Urban[b]	327.31/one-way lane mi
Airplane	Runway	N/A[g]	6,312/runway
	Gate	N/A[g]	78[c]/gate
HST Alternative			
High-Speed Train	At grade	Rural[d]	12.29/one-way guideway mi
		Urban[e]	19.11/one-way guideway mi
	Elevated	Rural[d]	55.46/one-way guideway mi
		Urban[e]	55.63/one-way guideway mi
	Below grade (cut)	Rural[d]	117.07/one-way guideway mi
		Urban[e]	163.14/one-way guideway mi
	Below grade (tunnel)	Rural[d]	117.07/one-way guideway mi
		Urban[e]	328.33/one-way guideway mi
	Station	N/A[g]	78[c]/station

[a] Estimates reflect average roadway construction energy consumption.
[b] Estimates reflect range maximum for roadway construction energy consumption.
[c] Value for construction of freight terminal. Used as proxy for unknown air gate and HST station consumption factors.
[d] Estimates reflect typical rail system construction energy consumption.
[e] Estimates reflect BART system construction energy consumption as surrogate for HST construction through urban area.
[f] Differences between the construction-related energy consumption factors for urban and rural settings reflect differences in construction methods, demolition requirements, utility accommodation, etc.
[g] Discreet (i.e., non-alignment-related facilities) are not differentiated between rural or urban because the data used to develop the respective values were not differentiated as such. Some difference between the actual values might be expected.

Sources: Congressional Budget Office 1977; Congressional Budget Office 1982 Congressional Budget Office in Energy and Transportation Systems, Prepared for the Federal Highway Administration, Sacramento, CA, by California State Department of Transportation (California Department of Transportation 1983); based on construction for air freight services.

Secondary Facilities: A *secondary facility* is a facility that consumes energy in the production of materials related to the project alternatives. For example, a factory that produces construction materials and machinery that would be used in the construction and maintenance of the alternatives' structures and attendant facilities would be a secondary facility. Potential impacts resulting from energy consumption of secondary facilities are discussed qualitatively. Consideration was given to whether nonrenewable resources would be consumed in a wasteful, inefficient, or unnecessary manner, (with special attention given to the efficiency of production of construction materials and machinery and the choices made regarding construction methodology and procedures, including equipment maintenance).

C. CRITERIA FOR DETERMINING SIGNIFICANCE OF IMPACTS

According to Appendix F of the CEQA Guidelines, the means to achieve the goal of conserving energy include 1) decreasing overall per capita energy consumption, 2) decreasing reliance on natural gas and oil, and 3) increasing reliance on renewable energy sources. The significance criteria discussed herein are used to determine whether the alternatives would have a potentially significant effect on energy use, including energy conservation.

The No Project Alternative is the primary basis against which potential impacts of the Modal and HST Alternatives are compared. Significant potential operational energy impacts would occur if the Modal or HST Alternative would result in either substantial demand on statewide and/or regional energy supply, or a significant additional capacity requirement; or significant increase in peak- and base-period electricity demand.

Significant potential construction-related energy impacts would occur if construction of either the Modal or HST Alternative would consume nonrenewable energy resources in a wasteful, inefficient, or unnecessary manner. Implementation of the Modal or HST Alternative would have a significant adverse effect if it, together with regional growth, would contribute to a collectively significant shortage of regional or statewide energy. By contrast, if the implementation of either alternative resulted in energy savings or alleviated demand on energy resources, the alternative would contribute to energy conservation and would have a beneficial effect.

3.5.2 Affected Environment

A. STUDY AREA DEFINED

The areas potentially affected by overall energy use of the alternatives are the regions comprising six of California's 15 air basins. (See Figure 3.3-1 in Section 3.3, *Air Quality*, for a map of the state's 15 air basins.) The following six air basins fall within the study area defined for overall energy use.

- San Francisco Bay Area.
- Sacramento Valley.
- San Joaquin Valley.
- Mojave Desert.
- South Coast.
- San Diego County.

At this program level of analysis, the data needed to model overall energy use are similar to those used to analyze air quality effects, which were also analyzed at the air basin level. (See discussion of air quality in Section 3.3.) The air basins used in this analysis were identified because the majority of intercity trips taken in California occur within them. Nearby air basins could also be affected by the project alternatives, but any impact would likely be minimal compared to impacts on the basins that physically contain the project alternatives.

At this program level of analysis, the area studied to determine the potential effects of the proposed alternatives on electricity generation and transmission was the entire state of California, since most of this infrastructure in the state contributes to the statewide grid. In general, any potential effects on electrical production which may result from the proposed alternatives would affect statewide electricity reserves and, to a lesser degree, transmission capacity. Some general discussion of potential effects on regional electricity production and transmission is included.

B. GENERAL DISCUSSION OF ENERGY RESOURCES

California is the tenth-largest worldwide energy consumer and is ranked second in consumption in the U.S. behind Texas. Of the overall energy consumed in the state, the transportation sector represents the largest proportion at 46%. The industrial sector follows at 31%, residential at 13%, and commercial at 10%. Petroleum satisfies 54% of California's energy demand, natural gas 33%, and electricity 13%. Coal fuel in California accounts for less than 1% of total energy demand. Electric power and natural gas in California are generally consumed by stationary users, whereas petroleum consumption is generally accounted for by transportation-related energy use (California Energy Commission 2000). A description of the existing energy resources and market conditions that could be potentially affected by the proposed alternatives is provided below.

Petroleum

Demand for transportation services (and, therefore, petroleum/gasoline consumption) in California mirrors the growth of the state's population and economic output. Historical trends coupled with current population and economic growth projections indicate that transportation sector use of gasoline and diesel fuels can be expected to increase by approximately 40% over the next 20 years; gasoline demand is projected to increase from 13.9 billion gallons (gal) (52.6 billion liters [L]) in 1999 to 19.9 billion gal (75.3 billion L) by 2020, and diesel from 2.4 billion gal (9.1 billion L) to 4.8 billion gal (18.2 billion L) over the same period. The California Energy Commission (CEC) projects that in-state oil refining capacity will lag behind this forecasted growth if major changes to the in-state oil refining industry are not made, which could contribute to long-term volatility in the price of both gasoline and diesel fuel (California Energy Commission 2000). Foreign petroleum imports account for approximately 29% of the state's petroleum supply, a percentage that would be expected to increase as in-state and Alaskan oil production declines (California Energy Commission 2002c).

The combination of the strong growth in gasoline demand, recently phased-out fuel additive methyl tertiary butyl ether (MTBE), significantly expanded use of ethanol necessitated by the federal minimum oxygen requirement, and transition to Phase 3 reformulated gasoline (RFG) could negatively affect the balance between supply of and demand for transportation fuels in California and impair the ability of refiners to supply consistent volumes of gasoline to meet California's demand. MTBE is a gasoline-blending component that was used as a gasoline oxygenate to help control carbon monoxide emissions before being phased out of gasoline sold in California (December 31, 2002). Phase 3 RFG prohibits use of MTBE and directs use of only ethanol as an oxygenate. Revisions of state and federal regulations to further tighten specifications for diesel fuel have been adopted to reduce environmental impacts. Together, these efforts to improve the environmental performance of petroleum fuels pose challenges for producing fuel volumes required to satisfy California's growing transportation-related fuel consumption. According to CEC staff, it would be difficult for the state to rely solely on petroleum-based fuels in the future, assuming a stable transportation fuel market is the desired outcome. (California Energy Commission 2000.)

Electricity

Electric energy is given consideration in this analysis because of the projected use of electric energy to power the proposed HST.

Existing State Electricity Supply and Demand: In-state electricity generation, which accounted for 85% of the 2001 total electrical supply, is fueled by natural gas (42.7%); nuclear sources (12.6%); coal[2] (10.4%); large hydroelectric resources (8.0%); petroleum (0.5%); and renewable resources, including wind, solar, and geothermal (10.5%). Electricity imports in 2001 were 15% of total production. Imports from the Pacific Northwest accounted for 2.6%, and 12.8% came from the Southwest. (California Energy Commission 2003.)

According to the CEC, total statewide electricity consumption grew from 166,979 gigawatt-hours (GWh) in 1980 to 228,038 GWh in 1990, at an estimated annual growth rate of 3.2%.[3] The 1990s saw a slowdown in demand growth because of the recession that lasted through the early and middle parts of the decade. The statewide electricity consumption in 1998 was 244,599 GWh, reflecting an annual growth rate of 0.9% between 1990 and 1998 (California Energy Commission 2002a). In 2001, statewide consumption was about 250,000 GWh (California Energy Commission 2002b).

Peak electricity demand, expressed in megawatts (MW), measures the largest electric power requirement during a specified period, usually integrated over one hour. A single MW is enough power to meet the expected electricity needs of 1,000 typical California homes (California Energy Commission 2003b). For comparison, one GW would be enough power for 1,000,000 typical homes. Peak demand is important in evaluating system reliability, determining congestion points on the electrical grid, and identifying potential areas where additional transmission, distribution, and generation facilities might be needed. California's peak demand typically occurs in August between 3 p.m. and 5 p.m. High temperatures lead to increased use of air conditioning, which, in combination with industrial loads, commercial lighting, office equipment, and residential refrigeration, comprise the major consumers of electricity consumption in the peak-demand period in California (California Energy Commission 2000). In 2003, according to CEC, peak electricity demand for California is predicted to be about 52,150 MW.[4] Peak-generating capacity for the state was expected to be about 59,696 MW[5] in 2003 (California Energy Commission 2003c).

Cal-ISO controls the electrical grid that distributes about 82% of the electricity consumed in the state, with the remainder being distributed by municipal utilities. A potential HST system would likely draw most of its electricity from the Cal-ISO-controlled grid, illustrated in Figure 3.5-1.

Electricity Supply and Demand Outlook

The CEC has conducted studies to predict the short- and long-term outlooks for electricity supply and demand balance in California. According to its 2003 staff report, *California's Electricity Supply and Demand Balance over the Next Five Years*, the CEC believes that the near-term

[2] Intermontane and Mohave coal plants are considered to be in-state facilities because they are in Cal-ISO-controlled areas.

[3] Electric energy is measured in watts (W): 1,000 watts is a kilowatt (kW); 1,000 kilowatts is a megawatt (MW); 1,000 megawatts is a gigawatt (GW). Electric consumption over time is measured in kilowatt-hours (kWh), megawatt-hours (MWh), and gigawatt-hours (GWh).

[4] Figure does not include 7% operating reserve.

[5] Figure includes net dependable generating additions of about 3,600 MW, as of July 2003, and forced and planned outages of 3,750 MW. Does not include spot market imports of 3,721 MW.

outlook for supply adequacy is promising. A 16% operating margin[6] is estimated for summer 2003 (assuming a 1-in-2-year peak temperature condition) in the Cal-ISO-controlled grid where supply is expected to outpace demand by approximately 6,000 MW[7] (California Energy Commission 2003c). According to CEC staff, a statewide planning reserve margin[8] of 8.8% is projected as far out as August 2008, when statewide supply capacity is anticipated to be 64,669 MW, outpacing a statewide projected demand of 59,459 MW[9] (California Energy Commission 2003c). The apparent decline in margins between the summers of 2003 and 2008 is due to the fact that the planning horizon for electric power resource additions is usually only two to three years out and does not necessarily indicate a downward trend in generating capacity.

This short planning horizon interjects uncertainty into the assessment of supply and reserve margin in 2020, the study year for the No Project, Modal, and HST Alternatives. However, the state has added substantial generating capacity in the last two years and it is reasonable to assume it will continue to add capacity. Between 2000 and February 2003, California licensed and added 18 new power plants which have contributed 4,980 MW to the statewide generating capacity. Power plants representing an additional 3,106 MW of generating capacity were anticipated to come online between February 2003 and August 2003 (California Energy Commission 2003d). Statewide demand in 2012 would most likely be around 64,845 MW, assuming normal summer temperatures (California Energy Commission 2002b). Using the growth trend that fits CEC demand predictions through 2012, published in the *2002–2012 Electricity Outlook* (California Energy Commission 2002b), demand for electricity in 2020 can be estimated to be on the order of 77,000 MW.[10] The Cal-ISO estimates that net additions of domestic electricity generation capacity and electricity imports of 1,000 to 1,500 MW/year will be necessary to maintain current operating margins (California Independent State Operator 2002b).

<u>Electricity Transmission Capacity Outlook</u>: Electricity transmission capacity refers to the maximum amount of power that can be carried from the generating source to the utility provider and is a key component in the electrical power delivery system. In the years since the start of the electricity crisis in the summer of 2000, the transmission capabilities of some portions of the state's electrical grid have occasionally been inadequate to transmit electricity at a rate that would satisfy demand. This phenomenon is known as transmission bottlenecks. An example of one such current bottleneck occurs through what is known as Path 15, a major transmission line between northern and southern California through the Central Valley. According to the Western Area Power Administration (WAPA), the Pacific Gas and Electric Company (PG&E) plans to increase the rating of Path 15 from 3,900 MW to 5,400 MW. This process is expected to be completed by 2004 (Western Area Power Administration 2002). Improvements to other transmission paths are also planned, for example the link between California and the Southwest (Palo Verde-Devers Path) and the interconnect with the Tehachapi wind resource area (Consumer Power and Conservation Financing Authority, Energy Resources Conservation and Development Commission, and California Public Utilities Commission 2003).

[6] *Operating margin* means the percentage by which supply outpaces demand; figure includes a 7% operating reserve in calculation (California Energy Commission 2003b).

[7] Figure includes operating reserve of 5,707 MW.

[8] *Planning reserve margin* differs from operating margin because it does not including the 7% operating reserve in calculation and does not account for forced outages or include spot market purchases. It is used in extended planning horizons (California Energy Commission 2003c).

[9] Demand projection assumes a normal summer. A hot summer increases projected demand to 62,914 MW, which corresponds to a 3.0% planning reserve margin.

[10] Projection to 2020 assumes an average annual growth rate of about 2.0%, with a range from between 1.5% and 3.9%. This projection is for comparison purposes only.

Natural Gas

California is the second largest consumer of natural gas in the nation, with consumption at more than 5.5 billion cubic feet (Bcf) (0.2 billion cubic meters [Bcm]) per day in 1997. Approximately 33% of this total daily consumption was for electricity generation. Residential consumption accounts for 25%, followed by industrial, resource extraction, and commercial. CEC's gas demand forecast projects continued growth at 1.3% annually, with volumes exceeding 7 Bcf (0.2 Bcm) daily by 2019. Natural gas supplies to California will remain plentiful for the next several decades. The total resource base (gas recoverable with today's technology) for the lower 48 states is estimated to be about 975 trillion cubic feet (Tcf) (28 trillion cubic meters [Tcm]), enough to continue current production levels for more than 50 years. Technology enhancements will continue to enlarge this resource base; however, increases to production capacity are less certain (California Energy Commission 1999). Production in the continental U.S. is expected to increase from 19.36 Tcf (0.55 Tcm) in 2001 base year to 32.14 Tcf (0.91 Tcm) in 2020 (U.S. Department of Energy 2003). As of 2001, in-state natural gas production accounted for 15% of total consumption. Out-of-state production areas include the Southwest (50%), the Rocky Mountains (10%), and Canada (25%) (California Energy Commission 2003a).

California's Natural Gas Market: Although California's natural gas market is affected by nationwide price conditions, it has taken steps to insulate itself from the full magnitude of the price swing amplitudes. Starting in 2000 to 2001, during the last major price elevation, the state's natural gas utilities obtained additional interstate pipeline capacity rights on the El Paso Interstate Pipeline in the fall of 2002. This addition allowed the state to maintain adequate inflow rates and reduce harm from price swings. During the recent price spike, pipelines serving California were running at 50% to 70% of capacity, indicating that excess capacity was available if it had been needed. The trend toward more pipeline capacity is being continued in California by projects such as the Kern River Expansion pipeline project, which became operational on May 1, 2003. Utilities in California have also invested in underground storage capacity, an effective mechanism for controlling annual costs that will allow them to dampen the effect of future severe price increases by drawing on stored gas instead of buying high-priced natural gas on the open market. Storage capacity was added in 1999 and in 2002 with the construction of Wild Goose Storage, located in Butte County, which can accommodate 14 Bcf (0.4 Bcm) (with the further expansion of 15 Bcf [0.4 Bcm] expected in 2004) and Lodi Gas, which can accommodate 12 Bcf (0.3 Bcm).

The State of California has also provided utilities with the flexibility and tools to manage gas costs by purchasing natural gas supplies under different contract lengths and pricing terms, and from a variety of supply sources. In addition, California is in the process of increasing its supplies of electricity from renewable power sources such as wind, geothermal, and solar energy. California legislation enacted in 2002 (Senate Bill 1078) created the Renewable Portfolio Standard (RPS) Program which will require retail sellers of electricity to increase their purchases of electricity generated by renewable sources, and establishes a goal of having 20% of California's electricity generated by renewable sources by 2017. Increasing California's renewable supplies will diminish the state's heavy dependence on natural gas as a fuel for electric power generation (California Energy Commission/California Public Utilities Commission 2003).

Relationship between Natural Gas and Electricity Resources in California

Increases in gas prices directly affect the price of electricity because of the large role that natural gas plays in electricity production throughout the Southwest—and in California in particular, where natural gas fueled 42.7% of electricity production in 2001. This percentage is likely to grow as the trend toward building natural gas power plants continues. During the spot-market price spike of February 2003, regional electricity prices rose 45% between early February 2003 and February 24, 2003, and an additional 150% between February 24 and February 26, 2003.

Since late February, natural gas prices have steadily fallen, and prices for electricity have followed suit (California Energy Commission/California Public Utilities Commission 2003).

Notwithstanding the relationship between conditions in the natural gas market and electricity prices, the functioning of the natural gas market, as well as the consequences of price changes in the natural gas market, are fundamentally different from the electricity market. Unlike electricity, natural gas has the property of storability, which gives natural gas an advantage as a commodity over electricity. Because electricity is not storable, a true long-term futures market cannot function as it does for durable commodities, and rates are determined almost solely by electricity spot markets. The lack of a futures market makes electricity rates susceptible to the effects of extreme swings in supply and demand. Conversely, the storability of natural gas provides the advantages that a fairly well-functioning futures market[11] offers with regard to upward pressure that risk puts on prices, and it allows utilities to buy natural gas when prices are low and store it until prices rise. In short, natural gas acts as any other durable commodity in the marketplace, including oil. Short-term shortages are mitigated by the above-stated mechanisms. Long-term price increases are corrected by increases in production capacity, the expectation of which, in turn, acts to bring prices down. Since the projected national in-the-ground natural gas reserves are expected to last for at least the next 50 years, actual supplies are not considered to be limiting, and short- and long-term prices are mostly a function of market conditions, assuming the trend toward improvements in production and transmission capacity continues (California Energy Commission/California Public Utilities Commission 2003).

<u>Transportation Energy Consumption</u>

Transportation accounts for a large portion of the California energy budget, with approximately 46% of the state's energy consumption resulting from the transport of goods and people. Between 1997 and 2020, according to the State Department of Finance, the state is forecasted to grow by about 11 million people, or approximately 30% (California Department of Finance 1998). During this same period, intercity travel is projected to grow by almost 40% to almost 215 million trips per year (California High Speed Rail Authority 2000). Although the average fuel economy of vehicles in the state has improved, the fuel savings achieved are overshadowed by the increased number of miles traveled and the marked shift in personal vehicle preference, from the standard passenger automobile (sedan) toward larger vehicles such as sport utility vehicles (SUVs) and pick-up trucks. Currently, California's 24 million automobiles consume more than 17 billion gal (64 billion L) of petroleum, most of which is consumed in southern California. The state is the third-largest consumer of petroleum fuel in the world. Only the United States as a whole and the former Soviet Union exceed this volume. Because of this dependence on petroleum fuels, events in the international petroleum market can immediately and adversely affect the price and adequacy of California's fuel supply (California Energy Commission 1999).

There are currently four options for intercity travel among the major urban areas of California: automobiles on interstate and state highways, commercial airlines, conventional passenger trains (Amtrak) on freight and/or commuter rail tracks, and long-distance commercial bus transit. These four modes of intercity travel represent a wide range of service characteristics, such as travel time and frequency. Automobiles and airplanes are the predominant modes of intercity trips longer than 150 mi (241 km).

The effects of transportation congestion on energy consumption and air emissions can be major. Automobiles are most efficient when operating at steady speeds of 35 mph to 45 mph (56 kph to 72 kph) with no stops (Oak Ridge National Laboratory 2002). Fuel consumption increases by

[11] The quality of data available to market analysts has been a source of some concern recently, although steps are currently being taken on the national level to remedy this situation.

about 30% when average speeds drop from 30 mph to 20 mph (48 kph to 32 kph), while a drop from 30 mph to 10 mph (48 kph to 16 kph) results in a 100% increase in fuel use. Studies estimate that approximately 10% of all on-road fuel consumed is a result of congestion (California Energy Commission 1990).

The analysis of transportation energy focuses on the overall energy consumption differences between the No Project, Modal, and HST Alternatives. This approach captures the two major transportation fuel inputs, petroleum oil and natural gas (a large component of electricity production). Electricity consumption as a specific item will also be analyzed because of the special nature of electricity, specifically its non-storability and its lack of suitability for trading in futures markets. It is reasonable that the analysis of energy consumed by the HST system is confined to electricity and does not include specific reference to natural gas. The price of natural gas is just one variable in the overall ability of the state's electricity-generating infrastructure to deliver adequate power to users. Moreover, it is not the total reserves of in-the-ground natural gas that is uncertain; it is the market conditions and production capacity trends that affect this commodity, just as is the case for the other major transportation fuel, petroleum oil.

3.5.3 Environmental Consequences

A. EXISTING CONDITIONS COMPARED TO NO PROJECT ALTERNATIVE

In 1997, the number of intercity passenger trips taken between regions of California that would be served by the proposed HST system was about 154 million (Charles River Associates 2000). Of these trips, 98% are attributable to automobiles or airplanes, and only 2% were taken via intercity conventional rail and bus. This result corresponds to 14,237 VMT (22,912 million vehicle kilometers traveled [VKT]) and 62 million airplane VMT (100 million VKT).

In 2020, under the No Project Alternative, the number of intercity passenger trips estimated to be taken in California is projected to be about 215 million (Charles River Associates 2000). This corresponds to about 18,866 million automobile VMT (30,362 million VKT) and 102 million airplane VMT (164 million VKT). The increase in intercity passenger trips is reflective of population growth expected over the same period, which is estimated by the California Department of Finance to be on the order of an additional 11 million people (California Department of Finance 1998).

<u>Operational (Direct) Energy</u>

As indicated in Table 3.5-3, the existing (1997 figures) energy used to power the estimated 154 million intercity passenger trips was 101,525,630 million Btus (MMBtus), or 17.5 million barrels of oil. The 215 million passenger trips estimated under the No Project Alternative would consume the equivalent of about 141,023,720 MMBtus, or 24.3 million barrels of oil. This increase of 39% from existing to No Project conditions would be caused primarily by a population increase of 11 million people. This is a conservative estimate because, as noted in Section 3.5.1, automobile fuel efficiency decreases considerably as travel speed decreases below 30 mph (48 kph) and stop-and-go traffic increases. Since congestion levels under the No Project Alternative would likely be higher than they are under existing conditions, the increase in direct energy used in 2020 would be higher than the projected 39% increase. To illustrate, if the direct energy consumption factor for automobiles under a congested No Project scenario increased by 5%, from 5,669 Btus/VMT to 5,952 Btus/VMT, the total direct energy consumption under the No Project Alternative would increase from 141,023,720 MMBtus to 146,371,202 MMBtus, which would represent a 44% increase over existing levels, compared to the 39% increase in direct energy consumption with the assumption of similar levels of service.

The No Project Alternative would potentially place additional demand on statewide energy supplies compared to existing conditions as a result of increased passenger trips, higher levels of congestion, and slower speeds on intercity highways.

Table 3.5-3
Annual Intercity Operational Energy Consumption in the Study Area

	1997 Existing	2020 No Project Alternative[f]
Annual VMT[b,c,g] (mi [km]) (millions)		
Auto	14,237 (22,912)	18,866 (30,362)
Airplane	62 (100)	102 (164)
HST	0	0
Annual Energy Consumption (Btus) (millions)		
Auto	80,711,153	106,949,635
Airplane	20,814,476	34,074,085
HST	0	0
Total Energy Consumption (MMBtus[a])	101,525,630	141,023,719
Change in Total Energy from Existing (MMBtus[a])		39,498,090
Total Energy Consumption (Barrels of Oil[e]) (millions)	17.5	24.3
Change in Total Energy from Existing (Barrels of Oil[e]) (millions)		6.8

[a] One British thermal unit (Btu) is the quantity of energy necessary to raise 1 pound of water 1 degree Fahrenheit.

[b] VMT based on average number of passengers per vehicle, by mode, as follows:
- Intercity auto: 2.4 passengers/automobile
- Airplane: 101.25 passengers/airplane (70% load factor per Business Plan)

HST VMT based on Business Plan (California High Speed Rail Authority 2000)

[c] Intercity travel only; long distance commute travel not included

[d] Rounded.

[e] One barrel of crude oil is equal to 5.8 MMBtus.

[f] Fuel consumption for No Project would increase beyond the figures presented here as speeds drop below 30 mph (48 kph) on congested highways.

Sources: [g] Charles River Associates 2002, Paul Taylor (Kaku Associates) pers. comm.

Peak-Period Electricity Demand

The No Project Alternative electricity consumption would increase slightly over existing conditions related to the programmed and funded airport expansion under the No Project Alternative. The possible future electrification of Caltrain, commuter rail systems, and/or Amtrak, which, though not part of the current No-Project Alternative, are being considered, would also increase electricity use. While these projects would be regionally significant, they are small in scale compared to overall electricity usage and would be captured by routine electricity consumption forecasts by CEC, allowing electricity generation and transmission planning to account for and accommodate their additions.

Potential electricity demand under the No Project Alternative would be satisfied by expected expansion in generating capacity. No significant potential impacts on electricity generating capacity have been identified.

Construction (Indirect) Energy
The No Project Alternative is based on the assumption that projects currently included in existing plans and programs, including local, state, and interstate transportation system improvements, would be implemented. It is assumed that construction of the projects included in the No Project Alternative would not result in the consumption of energy resources in a wasteful, inefficient, or unnecessary manner.

3.5.4 Comparison of Alternatives by Region

B. NO PROJECT ALTERNATIVE COMPARED TO MODAL AND HST ALTERNATIVES (with sensitivity analysis ridership forecasts)

Operational (Direct) Energy
The 39% increase in energy use of the No Project Alternative over existing conditions is similar to the potential increase that would be expected with implementation of the proposed Modal Alternative, which would increase direct energy consumption by 40% over existing conditions, as summarized in Table 3.5-4. By contrast, the proposed HST Alternative would increase direct energy consumption by 10% over existing conditions, a much slower rate than the Modal or No Project Alternatives.

Statewide: As indicated by the VMT-based analysis, energy requirements for intercity transportation would be greater under the Modal Alternative than under the No Project Alternative because of induced demand for automobile travel related to extra highway capacity. Table 3.5-4 shows that, although the number of airplane VMT would remain the same under Modal and No Project Alternatives,[12] the number of automobile intercity trips taken would increase statewide by 1.1% over the No Project Alternative,[13] which would increase the number of annual VMT by 208 million (335 million VKMT) to 19,073 million (30,695 million VKMT). These additional VMT translate into an additional energy use of 1,176,446 MMBtus, which is the equivalent of 0.2 million barrels of oil. However, as indicated in Section 3.5.1, automobile fuel efficiency decreases considerably as travel speeds decrease and stop-and-go traffic increases. This means that the higher energy consumption resulting from more VMT would be offset by the Modal Alternative's lower level of congestion in rural highway segments. For example, if the direct energy consumption factor for automobiles increased by 5% because of congestion under the No Project Alternative, from 5,669 Btus/VMT to 5,952 Btus/VMT, the total energy consumption under No Project would increase from 141,023,720 MMBtus to 146,371,202 BTUs. In this scenario, the Modal Alternative would consume 3% less direct energy than No Project. This compares to a 1% increase in direct energy consumption when comparing the Modal Alternative to a more congested No Project Alternative.

By comparison, the HST Alternative would potentially decrease intercity automobile VMT from 18,865 million (30,360 million VKT) under the No Project Alternative scenario to 15,816 million (25,453 million VKT), decrease airplane VMT from 102 million (164 million VKT) to 1 million (2 million VKT), and increase HST VMT attributable to intercity trips from 0 to 22 million

[12] It is assumed that an increase in the level of service for air travel under the Modal Alternative compared to the No Project Alternative would not increase the number of trips, but instead would meet peak travel demand. This could also be thought of as satisfying rush hour demand.

[13] Trips that would be induced (also called latent demand) as a result of the improved level of service.

(35 million VKT). Under the HST Alternative, commuter automobile VMT (based on 1.0 passenger per automobile) would also potentially decrease by 509 million VMT (819 million VKT) compared to the No Project Alternative, although HST VMT attributable to commuter trips would increase from 0 to 2 million (3 million VKT). Where the HST system would use 20,304,566 MMBtus for trips related to intercity travel, the overall direct energy for intercity travel would be 30,717,124 MMBtus, or the equivalent of 5.3 million barrels of oil, less per year than the 2020 No Project Alternative. This potential reduction represents a 22% energy savings for intercity trips over the No Project Alternative and a 9% increase over direct energy consumption under existing conditions (1997). Proposed HST operations related to commuter travel would use 1,630,199 MMBtus. However, the 10 million commute-related passenger trips that could be diverted from automobiles to the proposed HST system would result in a potential decrease in energy use by automobiles of 2,886,699 MMBtus. This would result in a net reduction in commute-related direct energy consumption of 1,256,500 MMBtus, compared to the No Project Alternative.

Table 3.5-4
Annual Intercity Operational Energy Consumption in Study Area

	1997	2020		
	Existing	No Project Alternative[g]	Modal Alternative[e]	HST Alternative[e]
Annual VMT[b, c, g] (mi [km]) (millions)				
Auto	14,237 (22,912)	18,866 (30,362)	19,073 (30,695)	15,816 (25,453)
Airplane[d]	62 (100)	102 (164)	102 (164)	1 (2)
HST	0	0	0	22 (35)
Annual Energy Consumption (MMBtus[a])				
Auto	80,711,153	106,949,635	108,126,081	89,661,289
Airplane	20,814,476	34,074,085	34,074,085	340,741
HST	0	0	0	20,304,566
Total Energy Consumption (MMBtus)	101,525,630	141,023,720	142,200,166	110,306,596
Change in Total Energy from Existing (MMBtus)		39,498,090	40,674,536	8,780,967
Change in Total Energy from No Project (MMBtus)			1,176,446	-30,717,124
Total Energy Consumption (Barrels of Oil[f]) (millions)	17.5	24.3	24.5	19.1
Change in Total Energy from Existing (Barrels of Oil[f]) (millions)		6.8	7.0	1.5
Change in Total Energy from No Project (Barrels of Oil[f]) (millions)			0.2	-5.3

[a] One British thermal unit (Btu) is the quantity of energy necessary to raise 1 pound of water 1 degree Fahrenheit.

[b] VMT based on average number of passengers per vehicle, by mode, as follows:
- Intercity auto: 2.4 passengers/automobile
- Airplane: 101.25 passengers/airplane (70% load factor)

HST VMT based on Business Plan (California High Speed Rail Authority 2000)

[c] Intercity travel only; long-distance commute travel not included.

[d] Does not include airplane VMT resulting from passengers making connections to other flights to continue or complete their journey because these are a minor portion of the HST-served market.

[e] Rounded.
[f] One barrel of crude oil is equal to 5.8 MMBtus.
[g] Fuel consumption for the No Project Alternative would increase beyond the figures presented here as speeds drop below 30 mph on congested highways.

Sources: [h] Charles River Associates 2002; Paul Taylor (Kaku Associates) pers. comm.

The VMT-based energy calculations above do not account for congestion levels. As congestion levels decrease, so does vehicular energy use for transportation. Therefore, the 22% energy consumption reduction projected under the HST Alternative is probably conservative because intercity route congestion levels would be expected to lessen in rural areas if it is implemented. Using the example of a 5% increase in the energy consumption factor for automobiles due to congestion, explained above under Modal Alternative, a congested No Project Alternative could hypothetically result in direct energy consumption of 146,371,202 MMBtus, compared to the 141,023,720 MMBtus anticipated in a less-congested No Project scenario. The congested scenario would result in additional intercity potential direct energy savings with the proposed HST Alternative of about 5,347,482 MMBtus, which would represent a potential 17% increase in the amount of energy saved. Thus, the total energy savings with the proposed HST Alternative and high-end ridership could be as great as 25% over the No Project Alternative.

An energy intensity analysis of the alternatives was also calculated using passenger miles traveled (PMT) for each of the modes. This is useful for anticipating how each of the alternatives would affect energy use. Table 3.5-5 lists the energy consumption factors of each of the modes. HST service offers a sharp reduction in energy consumption per passenger mile compared to other modes.

Table 3.5-5
Energy Consumption Based on Passenger Miles Traveled (PMT)

Mode	Energy Consumption[e]
Intercity Passenger Vehicles (Auto, Van, Light Truck) [a]	2,400 Btus/PMT
Commute Passenger Vehicles (Auto, Van, Light Truck) [b]	5,700 Btus/PMT
Airplanes[c]	3,300 Btus/PMT
High-Speed Trains[d]	1,200 Btus/PMT

[a] Based on 2.4 passengers per vehicle.
[b] Based on 1.0 passenger per vehicle.
[c] Based on 101.25 passengers per vehicle (70% load factor).
[d] Based on 761 passengers per 16-car trainset (63% load factor, which accommodates projected 2020 sensitivity case high-end demand for HST service within the existing Business Plan).
[e] Rounded.

Regional: In addition to the statewide direct automobile VMT savings that would result from travelers choosing HST travel, the proposed HST Alternative would potentially provide additional regional VMT reductions, compared to the No Project Alternative conditions. Proposed HST station-stops would be more numerous than airports, which would result in a lessening of the average distances required for passengers to travel from their points of origin to the mode transfer point (and vice versa) because of the likelihood that one or more of the stations would be closer to their point of origin than would their respective regional airport.

Implementation of the HST Alternative would also potentially decrease regional transportation-related energy consumption through proposed improvements to rail corridors in the Bay Area to Merced and Los Angeles to San Diego via Orange County (LOSSAN) regions. Grade separations are proposed for Caltrain and the LOSSAN corridor as part of the proposed HST system, which would increase traffic flow in the affected areas, thereby increasing fuel efficiency and decreasing energy consumption.

The comparison of the Modal and HST Alternatives to the No Project Alternative shows that only the proposed HST Alternative would potentially decrease energy use statewide. Compared to the Modal Alternative, the HST Alternative would save 31,893,570 MMBtus, or about 5.5 million barrels of oil annually, which equates to an approximate 22% savings. Regional analysis indicates that regional efficiencies, which would be precipitated by implementing the proposed HST Alternative, would increase these projected savings.

The Modal Alternative would have no potential impact because it would likely consume about the same, if not slightly less, energy than the No Project Alternative because of reduced congestion.

<u>Peak-Period Electricity Demand</u>

The small projected increase in electricity demand over existing conditions with the No Project Alternative would be somewhat smaller than what would be expected with implementation of the Modal Alternative. Conversely, the proposed HST Alternative would increase electricity demands on the state's generation and transmission infrastructure, increasing peak demand on the order of 480 MW[14].

<u>Statewide</u>: Compared to the No Project Alternative, there would be some increase in electricity demand in the peak period under the Modal Alternative due to new/expanded airport facilities. It would be small, and it would be covered by CEC projections of electricity demand and supply capacity.

By comparison, electrical power demanded by the HST system would increase the load on the statewide system on the order of 480 MW during peak electricity demand in 2020. Electricity supply and demand projections are not available for 2020. Such a long-time horizon has uncertainty, especially on the supply side, where capacity additions are difficult to predict more than two to three years into the future. However, it is useful to compare the expected HST-related operational electricity demand to surplus projections through 2008, the year that is farthest into the future for which electricity production capacity projections are available. CEC estimates that statewide electricity surplus generating capacity[15] in 2008 will be 5,210 MW, based on a total generating capacity of 64,669 MW and a demand of 59,459 MW (California Energy Commission 2003c). If the system were to become operational in 2008, the additional load (i.e., demand) placed on the system by the HST Alternative would be about 10% of the state's anticipated electricity surplus. Prediction horizons for demand estimates are longer than for capacity additions. The additional 480-MW load that would be placed on statewide electricity generating resources by the HST Alternative would represent approximately 0.7% of the CEC-predicted 2012 statewide electricity demand of 64,845 MW. Projecting the demand horizon to the study year of 2020, the HST Alternative-generated load would represent 0.6% of an

[14] Figure based on an average electricity use of 74.2 kW/train mi, which equates to an average electricity use rate of about 12 MW per trainset when integrated over 1 hour. These are averages and do not reflect acceleration or changes in grade; they are for planning purposes only.

[15] This assumes a normal summer and including existing generation, retirements, high-probability California additions, net firm imports, and spot-market imports.

estimated 77,000 MW statewide demand.[16] Though the HST Alternative could cause potentially considerable impacts on the state's electricity grid if the generation and transmission capacity were not equipped to handle the additional load, the short-term electricity generation outlook is favorable, and the medium- to long-term demand scenarios indicate that the proposed HST Alternative would represent a very small portion of statewide demand.

The demand growth extrapolation based on CEC demand predictions assumes an average annual electricity demand growth in California on the order of 1,400 MW through 2020, about three times the 480-megawatt load that the HST operations are expected to place on the statewide system. The HST Alternative would be built and become operational in stages, which indicates that, instead of placing an additional 480-MW load on the state's production and transmission resources abruptly, the system would gradually increase its electricity consumption rate to 480 MW. A first segment from Los Angeles to San Francisco, for example, would place an additional load on electricity resources on the order of 350 MW,[17] which is about 72% of the load anticipated for the entire system. This gradual increase would allow the in-state and out-of-state electricity generation and transmission industries and planners to anticipate and respond to the effects of the proposed HST Alternative on generating and transmitting resources.

Regional: Regional impacts on the electricity grid could occur if the proposed HST Alternative contributed to electricity transmission deficiencies, or bottlenecks, which were described in Section 3.5.2. If bottlenecks were to be aggravated by the HST Alternative, a potential adverse impact could result. However, through careful HST electrification design (i.e., design system so that it draws power from the electricity grid at several places throughout the state), it would be possible to minimize or eliminate such potential problems. Also, bottlenecks in the current grid system are being addressed by such projects as the Path 15 upgrade (see Section 3.5.2). If planning transmission line capacity continues to grow to anticipate statewide needs, the HST Alternative would not have the potential to cause a significant impact on transmission. The Modal Alternative is not expected to cause substantial electricity demand increases in any of the regions.

The HST Alternative could cause potentially considerable impacts on the state's electricity grid if the generation and transmission capacity were not equipped to handle the additional load. However, the short-term electricity generation outlook is favorable, and the medium- to long-term demand scenarios indicate that the proposed HST Alternative would represent a very small portion of statewide demand. If current trends continue as expected, electricity generation and transmission capacity would satisfy the underlying growth in demand, estimated to average about 2% per year. The HST Alternative would represent a small percentage of generating and transmission capacity required to satisfy projected overall demand. Staging of the completion of construction and the start of major operations would make the load additions by each of the HST Alternatives less abrupt than would be the case if the start of the full planned operations were to occur simultaneously.

Construction (Indirect) Energy

Construction of the programmed and funded transportation improvements under the No Project Alternative would require less energy than construction of either the Modal or HST Alternative.

[16] Calculation based on CEC demand projections from 2002 to 2012 for normal temperature years, published in *2002–2012 Electricity Outlook* (California Energy Commission 2002b). Projection to 2020 assumes an average annual growth rate of about 2.0% with a range from between 1.5% and 3.9%. This projection is for comparison purposes only.

[17] Figure determined by using the proportion of train-miles programmed into the operating plan between Los Angeles and San Francisco to the total number of train-miles for the entire completed project. Assumes that the rest of the operating plan (i.e., peak frequency) would remain the same.

Project Construction: The Modal Alternative construction-related energy consumption would result in the one-time, non-recoverable energy costs associated with construction of new/expanded airport runways, airport facilities, roadways—an estimated 2,970 lane-mi (4,780 km) statewide—interchanges, ramps, and other support facilities (e.g., rest areas, maintenance facilities). The HST Alternative construction-related energy consumption would also result in a one-time, non-recoverable energy cost, which would occur during construction of on-the-ground, underground and aerial facilities such as trackwork, guideways, structures, maintenance yards, stations, and support facilities. Details regarding energy conservation practices have not been specified for the HST Alternative, which has not been designed in detail, nor have construction methods and staging been planned at this time. Given the scope and scale of the improvements proposed as part of the HST Alternative, however, it is anticipated that the construction-related energy requirement would be substantial. Table 3.5-6 shows estimates of potential construction-related indirect energy consumption for both the Modal and HST Alternatives.

Table 3.5-6
Non-Recoverable Construction-Related Energy Consumption

Alternative	Structure	Rural vs. Urban[a]	Facility Quantity[b]	Energy Consumption[c] (MMBtus)
Modal	Highway (at grade)	Rural	1,476 one-way lane mi (2,375 km)[d]	25,187,000
		Urban	795 one-way lane mi (1,279 km)[d]	20,879,000
	Highway (elevated)	Rural	455 one-way lane mi (732 km)[d]	59,323,000
		Urban	245 one-way lane mi (394 km)[d]	80,191,000
	Subtotal			185,580,000
	Airport (runway)	N/A	6 runways	37,872,000
	Airport (gates)	N/A	91 gates	7,098,000
	Subtotal			44,970,000
	Modal Alternative total			230,550,000
HST	HST guideway (at grade)	Rural	2,263 guideway mi (3,642 km)	27,807,000
		Urban	640 (1,030 km)	12,224,000
	HST guideway (elevated)	Rural	333 guideway mi (536 km)	18,442,000
		Urban	161 (259 km)	8,972,000
	HST guideway (below grade, cut)	Rural	19 guideway mi (31 km)	2,239,000
		Urban	30 (48 km)	4,868,000
	HST guideway (below grade, tunnel)	Rural	242 guideway mi (389 km)	28,322,000
		Urban	146 (235 km)	47,958,000
	HST station	N/A	20 stations	1,560,000
	HST Alternative total			152,390,000

[a] Assumes the HST and Modal Alternatives would be constructed in rural and urban areas at the following proportions:
- Bay Area to Merced: Rural (70%), Urban (30%)
- Sacramento to Bakersfield: Rural (95%), Urban (5%)
- Bakersfield to Los Angeles: Rural (70%), Urban (30%)
- LOSSAN: Rural (30%), Urban (70%)
- Los Angeles to San Diego via Inland Empire: Rural (60%), Urban (40%)

[b] Measured in guideway miles for non-discrete structures (e.g., highways and HST guideways), and in structure quantities for discrete structures (e.g., airport runways and terminals, and HST stations).

[c] Rounded.

[d] Based on 2,970 mi (4,780 km) of highway lane additions; distribution between at-grade (65%) and elevated (35%) estimated for comparison purposes. True values are not known at current level of planning.

[f] Differences between the construction-related energy consumption for urban and rural settings reflect differences in construction methods, demolition requirements, utility accommodation, etc.

As shown in the table, the construction of the proposed HST Alternative would consume 34% less energy during construction than the Modal Alternative. Assuming that the 2020 energy savings for each of the system alternatives remain constant, and assuming an un-congested No Project scenario, the Modal Alternative would not repay the construction energy estimated to be consumed as a result of its implementation because more operational energy would be consumed by the Modal Alternative than by the No Project Alternative. If a 5% increase in the No Project Alternative automobile operational energy is assumed, the Modal Alternative would consume less energy than this congested No Project Alternative and would result in a construction energy payback period of 55 years. Energy savings projected for the proposed HST Alternative would repay the construction energy consumption in 5 years with an uncongested No Project scenario and would have a 4-year payback period if a 5% automobile congestion energy consumption penalty is assumed.

<u>Secondary Facilities</u>: It is reasonable to assume that secondary facilities, such as those used in the production of cement, steel, etc., would employ all reasonable energy conservation practices in the interest of minimizing the cost of doing business. Industry in California reduced electricity usage (which is mostly generated by natural gas, a nonrenewable fuel) from 54.7 million MWh in 2000 to 52.2 million MWh in 2001, a 4.6% reduction, even as the state's population increased by 513,352, or 1.5% (California Energy Commission 2002d). Therefore, it can reasonably be assumed that construction-related energy consumption by secondary facilities would not consume nonrenewable energy resources in a wasteful, inefficient, or unnecessary manner under either the Modal or HST Alternative.

Construction of either the Modal or HST Alternative is anticipated to take about 10 years, beginning in 2005 and finishing in 2016. Construction would occur in stages, and some segments would be open for operation while others are still under construction. Given the scope and scale of the Modal and HST Alternatives, it is anticipated that secondary construction-related energy requirements would be substantial.

Due to the scope and scale of the improvements proposed as part of the Modal and HST Alternatives, construction-related energy impacts, both project and secondary, would be potentially significant. Though the construction energy consumption factors presented in Table 3.5-6 indicate that the HST Alternative would consume less energy during construction than the Modal Alternative, how much less is unknown because limited data is available. Construction of the Modal and HST Alternatives would potentially represent a significant use of nonrenewable resources.

C. NO PROJECT ALTERNATIVE COMPARED TO MODAL AND HST ALTERNATIVES (with investment-grade ridership forecasts)

Operational (Direct) Energy

Statewide: Based solely on VMT, the HST Alternative with the investment-grade ridership forecast would potentially reduce overall direct energy use for intercity travel in 2020 by 11,749,680 MMBtus, or the equivalent of 2.0 million barrels of oil compared to the No Project Alternative, as shown in Table 3.5-7. This reduction represents an 8% energy savings for intercity trips over the No Project Alternative, and a 27% increase over direct energy consumption under existing conditions (1997). This compares to a 22% reduction over the No Project Alternative and a 9% increase over existing conditions (1997) with the high-end sensitivity analysis ridership forecast. Using the example of a 5% increase in the energy consumption factor for automobiles under congested No Project conditions, intercity direct energy savings with the HST Alternative would be 17,097,162 MMBtus with the assumption of investment-grade ridership projections, compared to a savings of 36,064,605 million Btus with the high-end ridership forecast. Commuter diversion to HST would not change with the investment-grade forecast.

Table 3.5-7
Annual Intercity Operational Energy Consumption in Study Area
(Assuming Investment-Grade Ridership Forecasts)

	1997	2020		
	Existing	No Project Alternative[g]	Modal Alternative[e]	HST Alternative[e]
Annual VMT[b,c,h] (mi [km]) (millions)				
Auto	14,237 (22,912)	18,866 (30,362)	19,073 (30,695)	17,367 (27,949)
Airplane[d]	62 (100)	102 (164)	102 (164)	41 (66)
HST	0	0	0	22 (35)
Annual Energy Consumption (MMBtus)				
Auto	80,711,153	106,949,635	108,126,081	98,458,799
Airplane	20,814,476	34,074,085	34,074,085	13,556,367
HST	0	0	0	17,258,873
Total Energy Consumption (MMBtus[a])	101,525,630	141,023,720	142,200,166	129,274,040
Change in Total Energy from Existing (MMBtus[a])		39,498,090	40,674,536	27,748,410
Change in Total Energy from No Project (MMBtus[a])			1,176,446	-11,749,680
Total Energy Consumption (Barrels of Oil[f]) (millions)	17.5	24.3	24.5	22.3
Change in Total Energy from Existing (Barrels of Oil[f]) (millions)		6.8	7.0	4.8
Change in Total Energy from No Project (Barrels of Oil[f]) (millions)			0.2	-2.0

[a] One British thermal unit (Btu) is the quantity of energy necessary to raise 1 pound of water 1 degree Fahrenheit.
[b] VMT based on average number of passengers per vehicle, by mode, as follows:
- Intercity auto: 2.4 passengers/automobile
- Airplane: 101.25 passengers/airplane (70% load factor)

HST VMT based on Business Plan (California High Speed Rail Authority 2000).
[c] Intercity travel only; long-distance commute travel not included.
[d] Does not include airplane VMT resulting from passengers making connections to other flights to continue or complete their journey, because they are a minor portion of the market served by HST.
[e] Rounded.
[f] One barrel of crude oil is equal to 5.8 MMBtus.
[g] Fuel consumption for the No Project Alternative would increase beyond the figures presented here as speeds drop below 30 mph (48 kph) on congested highways.

Sources: [h] Charles River Associates 2002, Paul Taylor (Kaku Associates) pers. comm.

With the investment-grade HST ridership projections, the energy consumption per passenger mile traveled on the HST would be about 1,800 Btus, compared to about 1,200 Btus when the high-end ridership forecast is assumed.

Regional: Regional energy savings with investment-grade ridership projections for the HST Alternative compared to the No Project Alternative would not be qualitatively different from those expected with the sensitivity analysis variations in the ridership forecast.

Peak-Period Electricity Demand

Whereas the proposed HST system would consume electricity at the rate of 480MW when fully operational with the sensitivity analysis variations in the ridership forecast, which would generally require 16-car trainsets to accommodate the expected passenger demand, the HST system would consume electricity at the reduced rate of 410MW[18] with the investment-grade ridership forecast, which would generally require 12-car trainsets to accommodate passenger demand.

Construction (Indirect) Energy

The HST Alternative would have a payback period of 12 years with the investment-grade ridership projections, compared to 5 years with the sensitivity analysis variations in the ridership forecast. Assuming a 5% increase in No Project automobile energy consumption due to congestion, the HST Alternative would have a payback period of 9 years with the investment-grade ridership projections, compared to 4 years with the sensitivity analysis variations in the ridership forecast.

3.5.5 Mitigation Strategies

This is a broad program-level analysis reviewing potential statewide energy use and impacts related to the proposed HST system and other alternatives. If the proposed HST Alternative were implemented, the HST system would be designed to minimize electricity consumption. The design particulars would be developed at the project-level of analysis, but would they include the following.

- Use regenerative braking to reduce energy consumption of the system.
- Minimize grade changes in steep terrain areas to reduce the use of electricity during peak periods.
- Use energy-saving equipment and facilities to reduce electricity demand.

[18] Based on an average electricity use of 63.07 kW/train mi, which equates to an average electricity use rate of the order of 10 MW per trainset when integrated over 1 hour. The rate of electricity use by a 12-car trainset was assumed to be 85% of the rate used by a 16-car trainset. These are averages and do not reflect acceleration or changes in grade; they are for planning purposes only.

- Maximize intermodal transit connections to reduce automobile VMT related to the HST system.
- Develop and implement a construction energy conservation plan.
- Develop potential measures to reduce energy consumption during operation and maintenance activies.

3.5.6 Subsequent Analysis

Subsequent analysis would be required in project-level environmental documentation for the proposed HST Alternative, if selected. Detailed analysis of base and peak-period electricity requirements and transmission infrastructure would be required to more precisely assess the adequacy of electricity generation and transmission capacity relative to demand for each segment to be pursued. Comprehensive traffic analysis for future conditions would be required to assess regional energy impacts in more detail for each segment.

Subsequent energy analysis at the project level would follow the methodology applied in this evaluation, but would employ the more detailed traffic and electrical input data for the energy consumption analysis. Energy consumption factors would be updated using the latest available published information. Detailed construction staging, sequencing, methods, and practices would be necessary to support a quantitative analysis of construction energy consumption.